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Characterization of Water Vapor in the North American Monsoon with JLH Mark2 and Aura MLS

Part 1: Measurements

Robert L. Herman, Robert F. Troy, Michael J. Schwartz, William G. Read, Dejian Fu, Lance Christensen
Jet Propulsion Laboratory, California Institute of Technology

Karen H. Rosenlof, Eric Ray
NOAA ESRL CSD, Boulder, CO

Kristopher Bedka
NASA Langley Research Center, Hampton, Virginia

T. Paul Bui
NASA Ames Research Center, Moffett Field, CA

Abstract

Several NASA ER-2 aircraft flights during the recent NASA Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) field mission sampled the UTLS region heavily influenced by the North American Monsoon (NAM). Enhanced water vapor was measured in the lower stratosphere between 160 hPa and 80 hPa over the continental United States. Here we present in situ water vapor measurements from the newly improved JPL Laser Hygrometer (JLH Mark2) to characterize the NAM water vapor field during August and September 2013. Regional context is provided by water observations from the Aura Microwave Limb Sounder (MLS) and back-trajectory models.

Water Vapor in the Lowermost Stratosphere

Recent publications have highlighted the importance of convectively injected water vapor into the lowermost stratosphere [Anderson et al., 2012; Schwartz et al., 2013]. We examine UTLS water vapor measured over the continental U.S. during the SEAC4RS time period.

JLH Mark2 Features

- Improved in-situ water measurements
- Athermal mechanical mounting for better optical stability
- Aerodynamic mirror holders for better optical stability
- Reduced noise on tunable diode laser (TDL) electronics for better precision
- Direct absorption spectral fitting for greater accuracy
- HITRAN 2012 linelist

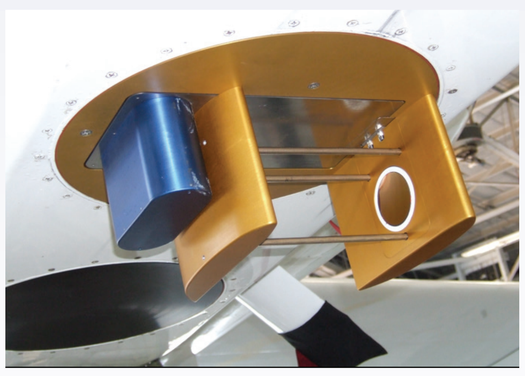

Figure 1. The JLH Mark2 instrument mounted in the forward Q-bay camera port of the NASA ER-2 aircraft during the SEAC4RS mission.

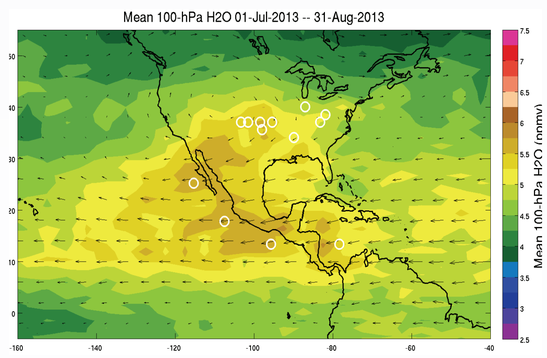

Figure 2. Aura MLS 100-hPa H2O (color scale), with superimposed MERRA horizontal winds (arrows) for July-August 2013 during the SEAC4RS time period. MLS observations of 100-hPa H2O greater than 8 ppmv in this two-month period are shown by the white circles.

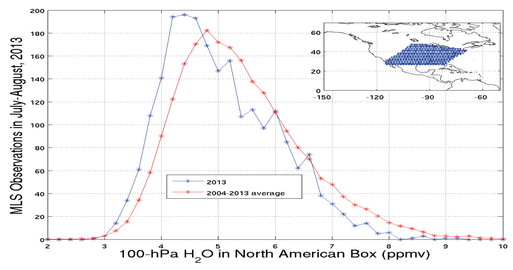

Figure 3. Distribution of Aura MLS July-August 100-hPa H2O over North America (blue shaded box) for 2013 (blue) and the 2004-2013 ten-year average (red).

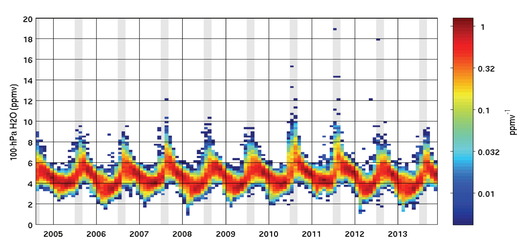

Figure 4. Time series of Aura MLS 100-hPa H2O over North America. Each monthly histogram is normalized to unity over mixing ratio. Dashed black vertical lines mark year boundaries, and gray-shaded areas denote July-August (after Schwartz et al., 2013).

JLH Water Vapor Profiles

Below are water vapor profiles measured by JLH during three NAM flights: 8 August, 14 August, and 16 August 2013.

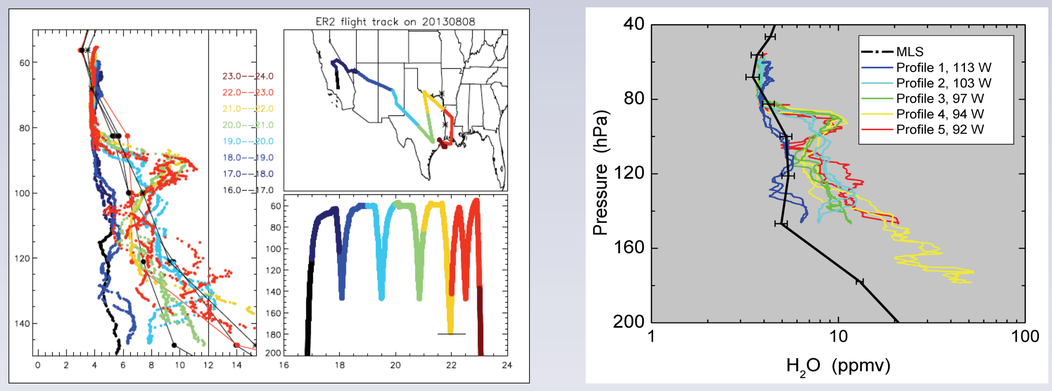

Figure 5. 8 Aug 2013 observations of LS water vapor by JLH and MLS.

Left panel: 8 Aug 2013 H2O profiles from JLH (dots color-coded by profile), coincident MLS scans (lines with circles), and JLH with the MLS averaging kernel applied (line with asterisks).

Lower right panel: time series of ER-2 pressure color-coded by profile. The MLS overpass and JLH data with averaging kernel applied are all from 22h UTC (yellow profile).

Upper right panel: ER-2 flightpath (color-coded by profile) and MLS geolocations (asterisks).

Far right: JLH water vapor color-coded by latitude.

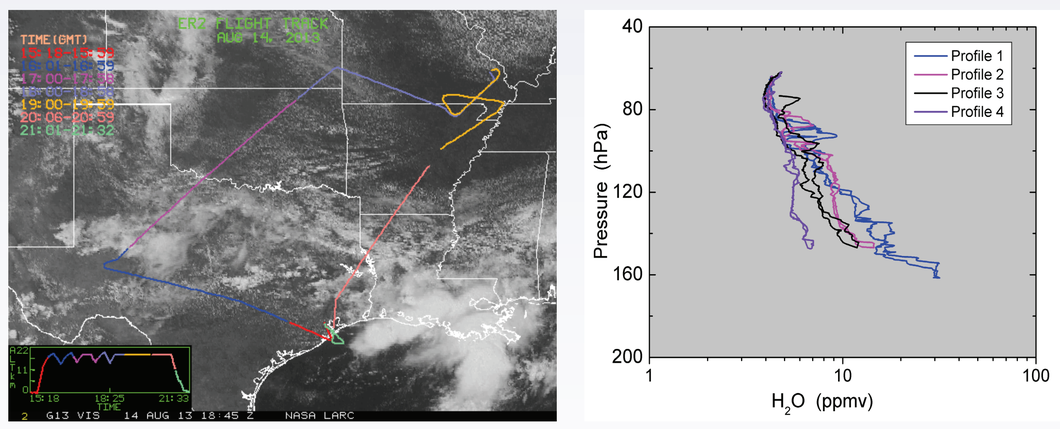

Figure 6. 14 Aug 2013 flightpath (left) and JLH water profiles (right), color-coded by profile.

The images were obtained from the NASA Langley Cloud and Radiation Research Group, http://angler.larc.nasa.gov/satimage/products.html.

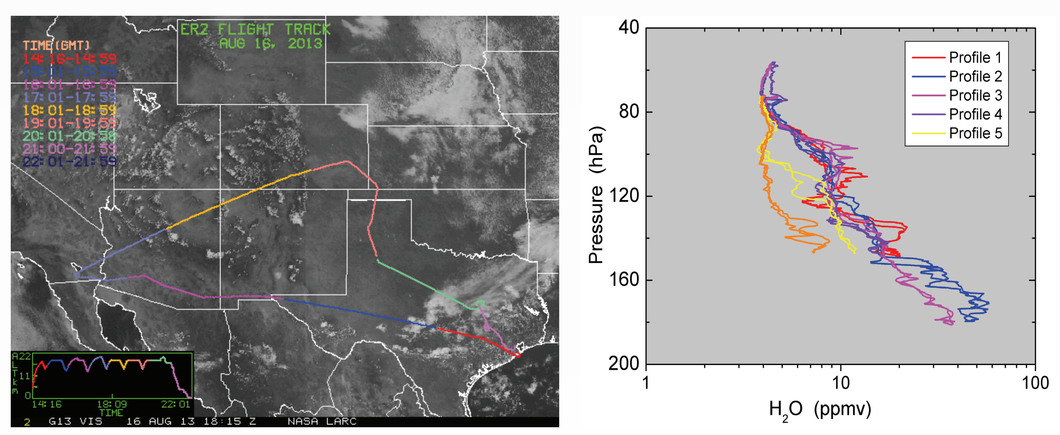

Figure 7. 16 Aug 2013 flightpath (left) and JLH water profiles (right), color-coded by profile.

The images were obtained from the NASA Langley Cloud and Radiation Research Group, http://angler.larc.nasa.gov/satimage/products.html.

Error Estimate

- Spectroscopic temperature dependence: 5%
- TDL wavelength tuning rate: 6%
- Spectral fitting in data analysis: 5%
- Absorption line strength: 3%
- Temperature and pressure: 1%
- Optical pathlength: 0.1%

Aura MLS Water

Figure 2 shows Aura MLS H2O at 100 hPa for July-August 2013. Individual events of H2O > 8 ppmv (white circles) are likely due to local convection. The broad feature of H2O > 5.5 ppmv is due to the NAM. Figures 3 and 4 compare Aura MLS H2O from July-August 2013 with the decade 2004-2013.

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